HYDROLOGIC RESOURCE MONITORING PARAMETERS

Wetlands Extent, Structure and Hydrology

Brief Description: Wetlands are complex and sensitive ecosystems, characterized by a water table at or near the land surface for some part of the year, by soil conditions that differ from adjacent uplands, and by vegetation adapted to wet conditions. Wetlands are usually classified on the basis of their morphology and vegetation and, to a lesser extent, their hydrology. Though definitions vary, the following types are widely recognized: coastal salt and freshwater marshes; swamps (mangrove, shrub and wooded); wet grasslands, meadows and prairies; and peatlands (landforms in which organic sediments have accumulated to depths in excess of 30-50 cm, including mires, moors, muskeg, bogs and fens).

The areal extent, distribution, and surface and internal structures of a wetland can be altered by many processes, such as organic and inorganic sediment deposition and erosion, paludification (lateral spread), terrestrialization (colonization of open water by wetland plant communities), and changing hydrology. In the case of coastal wetlands, saltwater intrusion and changes in sea level can also be important [see relative sea level, shoreline position].

Hydrological relationships play a key role in wetland ecosystem processes, and in determining structure and growth. Different wetlands have a characteristic hydroperiod, or seasonal pattern of water levels, that defines the rise and fall of surface and subsurface water. An important geoindicator is the water budget of a wetland, which links inputs from groundwater, runoff, precipitation, and physical forces (wind, tides) with outputs from drainage, recharge, evaporation and transpiration. Annual or seasonal changes in the range of water levels affect visible surface biota, decay processes, accumulation rates, and gas emissions. Such changes can occur in response to a range of external factors, such as fluctuations in water source (river diversions, groundwater pumping), climate or land use (forest clearing). Waters flowing out of wetlands are chemically distinct from inflow waters, because a range of physical and chemical reactions take place as water passes through organic materials, such as peat, causing some elements (e.g. heavy metals) to be sequestered and others (e.g. DOC, humic acids) to be mobilized.

A baseline of wetland conditions may be established through a paleoecological study to investigate whether a present-day wetland is stable or actively evolving, and if so in what direction and at what rate.

Significance: Wetlands are areas of high biological productivity and diversity. They provide important sites for wildlife habitat and human recreation. Wetlands mediate large and small-scale environmental processes by altering downstream catchments. The dissolved carbon burden of wetlands may affect downstream waters, eg. by acid drainage. Wetlands can affect local hydrology by acting as a filter, sequestering and storing heavy metals and other pollutants, such as Hg, and serving as flood buffers and, in coastal zones, as storm defenses and erosion controls.

Wetlands can act as a carbon sink, storing organic carbon in waterlogged sediments. Even slowly growing peatlands may sequester carbon at between 0.5 and 0.7 tons/ha/yr. Wetlands can also be a carbon source, when it is released via degassing during decay processes, or after drainage and cutting, as a result of oxidation or burning. Globally, peatlands have shifted over the past two centuries from sinks to sources of carbon, largely because of human exploitation. Some models of future climate change suggest that widespread thawing of permafrost peatlands due to climate warming, may lead to further emissions of greenhouse gases such as methane [see frozen ground activity].

Environment where Applicable: Wherever wetlands occur

Types of Monitoring Sites: Individual wetlands

Method of Measurement: Comparison of air photos, maps, charts and field surveys undertaken at different times. Important geological and biological parameters to be monitored include:

1. Areal extent and distribution, including changes in wetland boundaries (erosion, marine transgression). This is particularly important in sparsely inhabited areas, such as coastal swamps where changes in storm

surges and currents can cause severe damage within a single season, and permafrost terrains where melting may destroy coastal tundra landforms or flood peatlands, leading to their collapse.
2. Vegetation distribution: changes in occurrence of particular (indicator) species or in the distribution of various plant communities within a wetland. Permanent transects and plots can be set up for ease of data comparison and establishing temporal trends.
3. Surface morphology (e.g. development of hummocks and hollows in a smooth Sphagnum lawn may reflect disturbance of the wetland system)
These parameters can be investigated further by monitoring:
4. Hydroperiods, water budgets, and hydrochemistry: changes in water levels and in seasonality of flow patterns, which can be monitored via piezometers, wells, and weirs; variations in the chemistry of water inflows and outflows (salinity, heavy metals) that may herald significant changes in wetland structure and function.
5. Accumulation rates: changes in the rates of buildup of organic material and sediment (e.g. due to storm-introduced material in coastal sites), or in erosion of damaged sites. This is established either by setting up a stable vertical datum and periodically measuring the height of the wetland surface, or by inference from the paleo record.

Frequency of Measurement: Every 5-10 years for distribution, extent, and structure; before and after storms around coastal wetlands. For water budget and hydrochemistry, initial measurements should be weekly to monthly (more frequently in times of rapid change such as spring thaw) until important times and parameters have been identified, then less frequently.

Limitations of Data and Monitoring: Seasonal and annual variations in the natural system (e.g. hydrology, vegetation) may confuse interpretation, especially where air photos or satellite images are being used. Measuring water budget and chemistry is time-consuming and requires expensive equipment (e.g. automatic data loggers). It is difficult to identify and accurately measure all sources of inflow and outflow from a wetland, and few satisfactory models are now available. The separation of noise from signal is complex, and there is no such thing as a typical year. Moreover, collection of data is time consuming and labor-intensive.

Possible Thresholds: NA

Key References:

Berglund, B.E. 1986. Handbook of Holocene palaeoecology and palaeohydrology. New York: John Wiley.

Mitsch, W.J. & J.G.Gosselink 1993. Wetlands. 2nd Edition. New York: Van Nostrand Reinhold.

Morton, R.A. 1996. Geoindicators of coastal wetlands and shorelines. In Berger, A.R. & W.J.Iams (eds). Geoindicators: Assessing rapid environmental changes in earth systems:193-216. Rotterdam: A.A. Balkema.

National Wetlands Working Group, 1988. Wetlands of Canada. Ecological Land Classification Series 24, Environment Canada, Ottawa.

van der Linden,W.J.M., S.A.P.L.Cloetingh, J.P.K.Kaaschieter, W.J.E.van de Graaff, J.Vandenberghe & J.A.M.van der Gun 1989. Coastal lowlands - geology and geotechnology. Dordrecht: Kluwer Academic Publishers.

Warner, B. & J.Bunting 1996. Indicators of rapid environmental change in northern peatlands. In Berger, A.R. & W.J.Iams (eds). Geoindicators: Assessing rapid environmental changes in earth systems: 221-232. Rotterdam: A.A. Balkema.

Related Environmental and Geological Issues: Wetland management in inland and coastal areas, sediment erosion and deposition, basin subsidence, fluvial hydrology and groundwater, greenhouse gas sequestration and release. Wetland soils function as sinks for sulphates, nitrates and toxic substances, such as Hg, which can be released during floods or hot dry weather.

Overall Assessment: Wetlands are of major importance for agriculture, biodiversity, climate change, and human activities. Bioindicators for wetland environments are common, but improved understanding of these complex ecosystems will also require studies of their paleoenvironmental record and monitoring of their extent, structure, water budget and chemistry.

Source: This summary of monitoring parameters has been adapted from the Geoindicator Checklist developed by the International Union of Geological Sciences through its Commission on Geological Sciences for Environmental Planning. Geoindicators include 27 earth system processes and phenomena that are liable to change in less than a century in magnitude, direction, or rate to an extent that may be significant for environmental sustainability and ecological health. Geoindicators were developed as tools to assist in integrated assessments of natural environments and ecosystems, as well as for state-of-the-environment reporting. Some general references useful for many geoindicators are listed here:

Berger, A.R. & W.J.Iams (eds.) 1996. Geoindicators: assessing rapid environmental change in earth systems. Rotterdam: Balkema. The scientific and policy background to geoindicators, including the first formal publication of the geoindicator checklist.

Goudie, A. 1990. Geomorphological techniques. Second Edition. London: Allen & Unwin. A comprehensive review of techniques that have been employed in studies of drainage basins, rivers, hillslopes, glaciers and other landforms.

Gregory, K.J. & D.E.Walling (eds) 1987. Human activity and environmental processes. New York: John Wiley. Precipitation; hydrological, coastal and ocean processes; lacustrine systems; slopes and weathering; river channels; permafrost; land subsidence; soil profiles, erosion and conservation; impacts on vegetation and animals; desertification.

Nuhfer, E.B., R.J.Proctor & P.H.Moser 1993. The citizens' guide to geologic hazards. American Institute for Professional Geologists (7828 Vance Drive, Ste 103, Arvada CO 80003, USA). A very useful summary of a wide range of natural hazards.